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Reactive transport modeling of enhanced weathering as soil amendments for carbon removal

HANG DENG[1], NICOLAS SPYCHER[2], ERIC L SONNENTHAL[2], BHAVNA ARORA[2], MARKUS KLEBER[3] AND PETER S NICO[2]

[1]Peking University

[2]Lawrence Berkeley National Laboratory

[3]Oregon State University

Presenting Author: hangdeng@pku.edu.cn

Enhanced rock weathering combines both carbon capture and storage, and is a competitive option for carbon removal with considerable potential at intermediate costs. It has been estimated that enhanced rock weathering can sequester up to 2 giga tonne of CO2 per year if ground rocks are distributed in ~50% of the cropland globally [1]. However, there are still a lot of scientific unknowns, and a major source of uncertainty is the weathering rates. Our work aims to explore the controlling factors of weathering rates in the soil environment, and thus to inform experimental studies, field test and optimized practices. For this purpose, a 1D soil column was simulated under systematically varied chemical-physical conditions, using the multi-component multiphase reactive transport code TOUGHREACT. Our modeling results highlighted that operation parameters, specifically application depth and surface area, should be optimized based on the conditions at the application site. When atmospheric CO2 is the major source, well drained soils and/or lower infiltration rate will lead to higher weathering and carbonation rates. In contrast, when soil CO2 is the major source, as in the case when decomposition kinetics are high, increasing application depth will accelerate weathering. Furthermore, our observations highlight that the extent of increase in weathering rate is lower than the extent of increase in surface area, and can be alternatively achieved by leveraging other factors that are less energy intensive, e.g., proper siting and microbial interventions. The model used in our study also provide a valuable tool for considering site-specific conditions.

[1]Beerling et al. (2020), Nature, **583**, pages242–248.